**Conservation of Energy in the Combustion of Magnesium into Magnesium Oxide**

Laboratory Experiment

**Introduction**

Conservation of energy is a fundamental principle in thermodynamics. It is true across all sciences. In today’s lab we will observe this by calculating the heat of a reaction measured at constant pressure, or its enthalpy.

The purpose of this experiment is to determine the enthalpy of formation of a compound, magnesium oxide, MgO. The formation reaction is,

Mg(s) + ½ O2(g) → MgO(s) ΔH1 = ?

To determine ΔH1, we will perform two reactions and measure their enthalpy change using calorimetry.

Mg(s) + 2 H+(aq) → Mg2+(aq) + H2(g) ΔH2 = we will find this experimentally

MgO(s) + 2 H+(aq) → Mg2+(aq) + H2O(ϑ) ΔH3 = we will find this experimentally

½ O2(g) + H2(g) → H2O(ϑ) ΔH4 = this can be found in a data table

Once the three values, ΔH2, ΔH3 and ΔH4, are obtained, they can be used to combine those values such that the desired heat of formation can be calculated. The combination you use must follow Hess’s Law conventions.

**Equipment**

2- coffee cups , 8 oz

1 thermometer

1 piece of cardboard 10cm x10 cm

1-250 ml beaker

1-100 ml graduated cylinder

1 electronic scale, 0.001 g

**Reagents**

2 g magnesium ribbon

2 g magnesium oxide, reagent grade

500 ml HCl (1M, aq)

**Safety Procedures**

Wear safety goggles and apron at all times throughout the experiment. Wear long hair tie on back and close toe shoes. Hydrochloric acid is corrosive an should be handled with care. Magnesium oxide dust if inhaled. Do the sections that involve magnesium oxide under the hood.

Do not touch your face at any time. If you must, wash your hands thoroughly first.

Wash your hands before leaving the laboratory.

**EXPERIMENTAL PROCEDURE**

**PART I. Determining ΔH2 and The Relation Between the Quantity of Material Reacting and the Heat Transferred**

In this portion of the experiment we want to explore the relationship between the quantity of magnesium metal reacting with hydrochloric acid and the heat evolved by the reaction.

Mg(s) + 2 HCl(aq) → MgCl2(aq) + H2(g)

(a) Set up your coffee-cup calorimeter and support it in a ring stand or beaker as illustrated (See Figure below)



(b) Weigh out, to the nearest 0.001 g, three different portions of magnesium metal, say about 0.2 g, about 0.4 g, and about 0.5 g. Record the exact measured masses in the data table.

(c) Place one of the magnesium samples in a clean, dry coffee-cup calorimeter.

(d) Using a graduated cylinder, measure out as accurately as possible 100.mL of 1.0 M HCl. Measure the temperature of the HCl solution and record this initial temperature on the report form. Replace the thermometer in the calorimeter setup.

(e) Add the HCl solution to the calorimeter quickly, cover it immediately and swirl gently but steadily. At 30 second intervals record the temperature (to the nearest 0.5 ˚C) until the temperature has held constant or decreased for three consecutive readings.

***Weigh the cup before adding the liquid and at the end of the experiment.***

(f) Repeat the steps above with another sample of Mg. Do all three samples, making sure the calorimeter is clean and dry each time.

(g) In each case, determine ΔT, the change in temperature between the temperature of the HCl solution before adding it to the magnesium and the maximum temperature of the reacting system. If you were to plot the temperature of the reacting system versus time, you would see something like that illustrated here.

At the point where the temperature becomes constant, you have reached thermal equilibrium, no more heat is flowing. Record that temperature as Tf in your data table.

Calculate ΔT = T f – T i

**PART II: Determining ΔH2: Heat of Reaction of Magnesium Oxide with Hydrochloric Acid**

(a) Set up the calorimeter as in PART I. Make sure it is clean and dry.

(b) Weigh out about 0.7 g of MgO to the nearest 0.001 g and place the powder in the calorimeter.

(c) Repeat steps (d) and (e) as in PART I above.

***Repeat this MgO experiment with another sample of magnesium oxide.***

**Calculations**

In each reaction, we will assume that the calorimeter absorbs no heat. Therefore, the amount of heat energy released is determined by the temperature rise of the solution. Each solution is diluted, so we will assume that they have a specific heat capacity of 4.18 J/g⋅oC and a density of 1.00 g/mL.

Use the equation,

Q =Heat of reaction in joules = Specific heat capacity x mass (g) x ΔT

to determine the quantity of heat released. Then, using this and the number of moles of compound reacting, determine the value of ΔH for each reaction.

ΔH =

Remember that if heat is released, then ΔH must be a negative value.

Use the three reactions performed in Part 1 to verify if the amount of heat released is proportional to the number of moles of compound reacting. **Report** on whether this is true (compare with values given in the literature and calculate percent error)

Use the ΔH values determined experimentally as well as that for formation of H2O liquid to calculate the value of ΔH of formation for MgO(s). To do so, you must find a way of combining the three reactions for which you know ΔH so that they add up to give the reaction of interest. Remember that you can use Hess’ Law conventions such as reverse reactions (and switch the sign of ΔH) or multiply reactions by a coefficient (and then must multiply the ΔH by that same number). Report how you do this calculation and the final value of the heat of formation of MgO(s).

Critical Thinking Analysis

Calculate the percent error for the heat of formation of magnesium oxide you obtained in the lab with the one published in the literature of -601.8 kJ/mol. Explain the percent error you calculated. If you lost/gain heat, list all the possible places it might have gone/come from.



Combustion of magnesium ribbon

Critical Thinking Applications

The Calorie mentioned in connections with foods is actually equal to 1 kilocalorie. If 4.18 joules are equal to 1 calorie and a cup of ice cream releases 200 kilocalories, how many cups of ice cream release the same amount of energy as the reaction producing one moles of water from its constituent gases?